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FINAL REPORT

LAKE ENHANCEMENT PROGRAM FEASIBILITY STUDY FOR LAKE SALINDA

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EXECUTIVE SUMMARY

Lake Salinda, located in Washington County, is a man-made, secondary potable water supply reservoir and is located two miles south of the City of Salem. It has an approximate surface area of 65.8 acres, a mean depth of 13 feet, a maximum depth of 28 feet with a watershed of 3412.9 acres. The reservoir is situated on Hoggatt Branch, a tributary of the West Fork of the Blue River. The reservoir was constructed in 1947 and enlarged in 1965. The watershed is predominantly agricultural with cropland comprising 43.6 percent and pasture comprising 32.4 percent. Problems concerning siltation were recorded in the early 1960s, and algae problems have been reported since the mid 1970s.

The objectives of this feasibility study were to assess the current characteristics of the lake and its watershed, identify the eutrophication problems, their sources and relative contributions, and develop restoration alternatives recommending the most practicable and potentially successful alternative.

Currently, Lake Salinda is undergoing the severe consequences of sediment and nutrient loading from non-point source pollution. The evidence is the nutrient and suspended solids concentrations in storm runoff, the populations of nuisance algae, and the decrease in lake surface area and volume due to sedimentation. The lake was originally a 126 acre reservoir; it is currently a 65.8 acre reservoir for a net loss of 48 percent of lake surface area. The primary source of this non-point source pollution is the agricultural cropland of the watershed due to highly erodible soils, tillage methods, cropping practices and fertilization methods.

The restoration of Lake Salinda must primarily concentrate on the applicaiton of T by 2000 land treatments by developing and implementing Best Management Practices (BMPs) on the lake watershed. Specific BMPs would include conservation tillage, set-aside acreage, contour farming, contour strip cropping, animal waste management, livestock exclusion and streamside management zones. After implementing land treatments and

limited further analysis, a two-phase in-lake treatment of lake drawdown and alum treatment is recommended. Lake drawdown during the winter by five feet would consolidate the inlet sediments, thus increasing lake volume, with alum treatments the following early spring to precipitate out dissolved phosphorus suspended in the lake pool at peak concentrations.

The City of Salem officials, local landowners, municipal water utility customers and other concerned users of Lake Salinda should be made aware of the significant erosion problems on the watershed and the necessary actions required to restore the lake to an improved condition. Active, consistant management of the lake, its tributaries, shoreline and watershed must be provided for the lake to continue to function as a water supply and recreational reservoir.

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SECTION 1. INTRODUCTION

Lake Salinda is a man-made, water supply reservoir located approximately two miles south of the City of Salem in Washington County, Indiana. The lake has an approximate current surface area of 65.8 acres, a recorded maximum depth of 26 feet and an average depth of 13 feet. The dam is a zoned, rolled-earth embankment with a clay core and an ogee weir for the principle spillway. There is no emergency spillway, but drawdown facilities are provided by a 4-foot by 5-foot sluice gate and outlet conduit to Hoggatt Branch. There is also a raw water pump station and intake structure with intake elevations at 8.5 feet, 16.5 feet and 24.5 feet below average lake pool level. The lake is situated on Hoggatt Branch, a tributary of the West Fork of the Blue River, and receives approximately 5.3 square miles of drainage. The lake and its watershed lie within parts of Sections 28, 29, 32, and 33, Township 2 North, Range 4 East on the Salem, U.S.G.S. 7.5-Minute Quadrangle Map dated 1963 and photoinspected 1978. The City of Salem's Board of Public Works maintains the lake and adjacent municipal property with Lake Salinda serving as a secondary potable water supply to the City. The City provides public access to shore fishing, a boat ramp for on-lake activities, and picnic areas.

Construction at Lake Salinda was completed in 1947. By 1952, discussions were held concerning increasing the water supply volume of the lake. In 1965, construction was completed and involved widening the spillway from 75 feet to approximately 150 feet, raising the crest from 720.0 MSL to 722.5 MSL and changing the shape from a broad-crested weir to an ogee section.

Previous surveys and investigations include a sedimentation study in 1964 by a private contractor that determined a 14 percent loss in original storage capacity of the lake, and Fish Management Reports by the Division of Fish and Wildlife in 1964, 1971, 1974 and 1979. The 1979 survey found carp in the lake, as well as healthy populations of panfish and bass. Carp had never been reported in earlier surveys, yet they ranked fifth by number and first by weight. Catfish stockings have occurred since 1978, but there is no more recent fisheries survey.

An additional survey also includes an investigation by the Indiana State Board of Health, Division of Sanitary Engineering, in August of 1987, studying the soil and geological conditions on the south side of Lake Salinda proposed for a residential subdivision. It concluded that based on soil texture and depth, stoneline depth, seasonal high water table and geologic conditions, comprehensive plans by a soil scientist and engineer would be necessary on a site-by-site basis before on-site sewage disposal permits could be considered by the Washington County Health Department for this area. It was further strongly suggested that a central wastewater collection system be the first consideration.

The Division of Fish and Wildlife, in their Fish Management Reports, have recorded the surface area of the lake at 126 acres, yet a 1979 U.S. Army Corps of Engineers, Phase I Dam Inspection of Lake Salinda recorded the surface area at 86 acres. The current determination of the lake's surface area is 65.8 acres, obtained from current aerial photography. This is only 52 percent of the original surface area. Lake Salinda has lost 48 percent of its area in the past four decades. Based on the 1979 and 1989 figures, Lake Salinda is losing approximately 2 acres per year of surface area.

The feasibility study was conducted to evaluate the existing conditions at Lake Salinda. The specific areas of concern were sedimentation of the inlets, aquatic weed problems, and nutrient loading. The study was also to evaluate the potential environmental impact of residential areas proposed to be established immediately adjacent to the lake. The study encompasses these concerns and presents our findings, conclusions, and recommendations.

SECTION 2. EXISTING CONDITIONS

A preliminary reconnaissance of the Lake Salinda basin was conducted during April of 1988 to obtain background data necessary to prepare an evaluation of the lake. The lake reconnaissance conducted on August 4, 1988, surveyed the sedimentation, the proliferation of aquatic plants in the lake pool including the algae population, and the lake pool water quality. Storm sampling was conducted for a 1.7-inch, 6-hour storm event on July 20-21, 1988. The existing conditions as determined during the study are presented in the following sections of this report.

2.1 Water Quality

Lake stations were established to identify existing conditions of the lake influent, effluent, and pool. Figure 1 shows the locations of the sampling sites and Table 1 provides a description of the sampling sites. Each sampling station was evaluated for a specific set of field and laboratory parameters as summarized in Table 2. The results of the field and laboratory analyses for the lake stations are summarized in Table 3. The laboratory data sheets are contained in the Appendix.

The methods providing for the collection and preservation of water samples involved the use of clean, rinsed, one liter Cubitainer containers to provide for the analysis of nutrient concentrations, total suspended solids, and copper. Plankton samples were preserved and stained with potassium iodide solution and quantified using a Sedgwick-Rafter cell. Sediment samples were collected in one-quart glass containers. All samples were stored and transported at 4°C in insulated coolers.

The equipment used during the lake reconnaissance consisted of a Hydrolab Surveyor II, a Martek transmissometer, a Secchi disk, an Eagle depth finder, a Kahlisico column sampler, and a Monark boat. The Hydrolab Surveyor II is a multi-probe instrument capable of in-situ measurements of pH, specific

LAKE SALINDA

FIGURE #1

SALEM, IND.
USGS MAP
1"-2000'

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TABLE 1.

MONITORING STATIONS
LAKE SALINDA

SITE ID	SITE DESCRIPTION	PARAMETER LIST
LS1	Lake Salinda - effluent at spillway	C
LS2	Lake Salinda - pool, near water plant intake	B
LS3	Lake Salinda - pool, near mid-point	B
LS4	Lake Salinda - pool, near boat launch ramp	B
LS5	Lake Salinda - pool, in largest tributary	B
LSS1	Lake Salinda - sediment sample in watershed section 2	D
LSS2	Lake Salinda - sediment sample in watershed section 3	D
LSS4	Lake Salinda - sediment sample in delta in largest tributary	D
LSS5	Lake Salinda - sediment sample in watershed section 5	D
LSR1	Lake Salinda - storm sample, lake influent	A
LSR2	Lake Salinda - storm sample, lake influent	A
LSR3	Lake Salinda - storm sample, lake influent	A
LSR5	Lake Salinda - storm sample, lake influent	A
LSR6	Lake Salinda - storm sample, lake influent	A
LSR7	Lake Salinda - storm sample, lake influent	A

TABLE 2.

FIELD AND LABORATORY PARAMETER LIST
LAKE SALINDA

A. LAKE INFLUENT

Field:	Laboratory:
Temperature	Total Phosphorus
pH	Dissolved Phosphorus
Discharge	TKN
	Nitrate
	Ammonia
	Total Suspended Solids
	Dissolved Oxygen
	Specific Conductance

B. LAKE POOL

Field:	Laboratory:
Temperature	Total Phosphorus
Dissolved Oxygen	Dissolved Phosphorus
pH	TKN
Specific Conductance	Nitrate
Light Transmission	Ammonia
Secchi Disk Reading	Total Suspended Solids
Depth Reading	
	*Copper

C. LAKE EFFLUENT

Field:	Laboratory:
Temperature	Total Phosphorus
Dissolved Oxygen	Dissolved Phosphorus
pH	TKN
Specific Conductance	Nitrate
Discharge (Estimated)	Ammonia

D. SEDIMENT CORES

Laboratory:

Total Phosphorus
Dissolved Phosphorus
TKN
Nitrate
Ammonia

* Analysis performed on sample from LS2, 25-foot depth only.

TABLE 3.

LABORATORY TEST RESULTS
LAKE SALINDA

SITE	DEPTH (ft)	TSS (mg/L)	NO_3-N (mg/L)	NH_3-N (mg/L)	TKN (mg/L)	P^T (mg/L)	P^D (mg/L)	CU^T (mg/L)
LS1	0	8	0.8	0.07	1.85	0.07	<0.01	---
LS2	0	8	0.7	0.06	1.85	0.06	<0.01	---
	5	8	0.8	0.09	1.30	0.06	<0.01	---
	25	16	<0.05	2.43	3.70	0.22	0.01	0.61
LS3*	(0-18')	8	0.9	0.38	1.24	0.13	0.01	---
LS4*	(0-10')	11	0.8	0.21	1.40	0.10	<0.01	---
LS5*	(0-4')	12	<0.05	0.22	0.86	0.11	<0.01	---

* Composite Sample

TSS - Total Suspended Solids

NO3-H - Nitrate as Nitrogen

NH3-H - Ammonia as Nitrogen

TKN - Total Kjeldahl Nitrogen

P^T - Total Phosphorus

P^D - Dissolved

Cu^T - Total Copper

--- - Not Monitored

TN = TKN + NO2 + NO3

TKN = NH3-N + Organic N

conductance, dissolved oxygen, and temperature at any depth up to 250 feet. The Martek transmissometer measures the intensity of light which gives a measure of turbidity and aids in defining the thermocline. The Secchi disk was used to measure the transparency of the lake. The Eagle depth finder was used to sound inlets for sediment deposition. The Kahlisico column sampler is used to collect a sample of water at any given depth up to 500 feet. The Monark boat, which housed all the equipment, is specially designed for lake sampling.

There was no discharge observed over the spillway at Station LS1 during the field survey on August 4, 1988. However, the spillway was leaking just below the crest and the discharge was estimated to be 75 gallons per minute (GPM). Total suspended solids (TSS) was 8 mg/L in the lake effluent and the nutrient concentrations were moderately low. The discharge water quality was very similar to the pool site LS2.

The deepest lake station, LS2, had a depth of 28 feet and was sampled near the dam and spillway. A plot of the field data is shown in Figure 2. The data show gradual decline in temperature as the probe was lowered deeper in the pool exhibiting a gradient difference of 17.2°C (degrees centigrade). A similar but less dramatic response was observed in pH. Values ranged from 9.1 at the surface to 6.8 at a depth of 25 feet. Dissolved oxygen declined gradually to an approximate depth of 10 feet where a concentration of less than 1.0 mg/L was measured. Percent light transmissivity showed a gradual decrease from 19 percent at the surface to 0 percent at 20 feet. The exception of one significantly higher reading of 28 percent was measured at 7.5 feet. The sudden increase in light transmissivity at this depth corresponds to the interval just below the algal zone and, therefore, is probably clearer than other intervals. Specific conductance was almost constant in the upper 10 feet (202 to 229 umhos/cm), but increased at depths below 10 feet due to decreased oxygen levels and increased reducing environment. The Secchi disk reading was 3.2 feet and is an indication of light penetration and reflection through the water column. Most of this pattern is typical of field measurements for second-class lakes.

At Station LS2, the concentration of inorganic nitrogen was 0.76 mg/L at the surface and 0.89 mg/L at 5 feet below the surface. Dissolved phosphorus was less than 0.01 mg/L at the same sampled intervals. These data suggest limiting conditions for algae production. However, the inorganic nitrogen content at 25 feet below the surface was considerably higher at over 1.0 mg/L. Dissolved phosphorus was less than 0.01 mg/L and the total copper content was 0.61 mg/L at the 25-foot sampling depth. Copper sulfate has been used as an algicide and is assumed to be the source of the copper measured at this station. Copper has a permissible criterion of 1.0 mg/L (EPA National Secondary Drinking Water Regulations, 1979) with a desirable criterion of being virtually absent from public water supplies due to its undesirable taste. Profiles for Station LS2 are provided as Figure 2.

Lake pool Station LS3 was located approximately 1800 feet upstream of the dam and had a recorded total depth of 18 feet. As shown in Figure 3, the relationships between water quality and sampling depth observed at Station LS3 are nearly identical to the patterns observed at Station LS2. Dissolved oxygen, and temperature decreased from the surface to the lake bottom. A dramatic decrease in dissolved oxygen was observed between the 5-foot and the 7.5-foot depth measurements: 7.5 mg/L to 1.0 mg/L due to thermal stratification. pH declined steadily from 9.1 at near surface to 7.2 at lake bottom. Specific conductance remained relatively constant at 197 to 234 umhos/cm from the surface to a depth of 10 feet. From 10 to 18 feet, specific conductance increased to 428 umhos/cm due to highly favorable reducing conditions. Overall light transmissivity averaged about 5 to 10 percent higher than Station LS2, but a similar response to the 7.5 feet depth was observed. The Secchi disk reading was 3.2 feet. A composite sample collected from the surface to a depth of 18 feet contained 1.28 mg/L of inorganic nitrogen, but only 0.01 mg/L of dissolved phosphorus.

Pool Station LS4 is located approximately 3100 feet upstream from the dam and across from the boat launch ramp. The total depth of Station LS4 was 10 feet. As shown in Figure 4, most of the water quality field determinations showed a gradual decrease with depth. Dissolved oxygen, pH, and temperature declined steadily from the surface to the lake bottom due to shallow water depth (D.O. 11 mg/L to 1.2 mg/L, pH 9.1 to 7.5, and temperature 32.6°C to 24.2°C). Specific conductance was nearly constant throughout the lake profile with an average value of 235 umhos/cm. Light transmissivity ranged around 20 percent but decreased to only 1 percent at a depth of 10 feet. Due to the shallowness of this station, no anomaly was evidenced in the light transmissivity data. The Secchi disk reading was 2.7 feet. A composite sample collected at Station LS4 contained 1.01 mg/L inorganic nitrogen and 0.01 mg/L of dissolved phosphorus.

The final lake station profiled was LS5. This station was located 0.9 miles from the dam in the north finger of the lake. The lake was very shallow in the area of Station LS5, averaging only four feet in depth. The field parameters measured at Station LS5 show the same basic trends observed at the other lake stations profiled. As shown in Figure 5, dissolved oxygen, temperature, pH, and light transmissivity decreased gradually with increasing depth. Specific conductance increased slightly from the surface to the lake bottom. Nutrient analysis of a composite sample from Station LS5 resulted in an inorganic nitrogen content of 0.72 mg/L and dissolved phosphorus concentration of less than 0.01 mg/L.

From observations made at the lake, it is clear that Lake Salinda is eutrophic with moderately high algae production. Nutrient analysis of the lake generally showed that while inorganic nitrogen appeared to be readily available, dissolved phosphorus concentrations were below the 0.01 mg/L requirement for additional aquatic plant growth. Nutrient concentrations in the lake are not limiting at critical times as evidenced by the overproduction of algae and other aquatic plants. It is likely that a significant influx of nutrients is introduced into the lake during storm events.

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FIGURE 2.
Selected Water Quality Parameters vs. Sampling Depth at Lake Salinda, Station LS2.

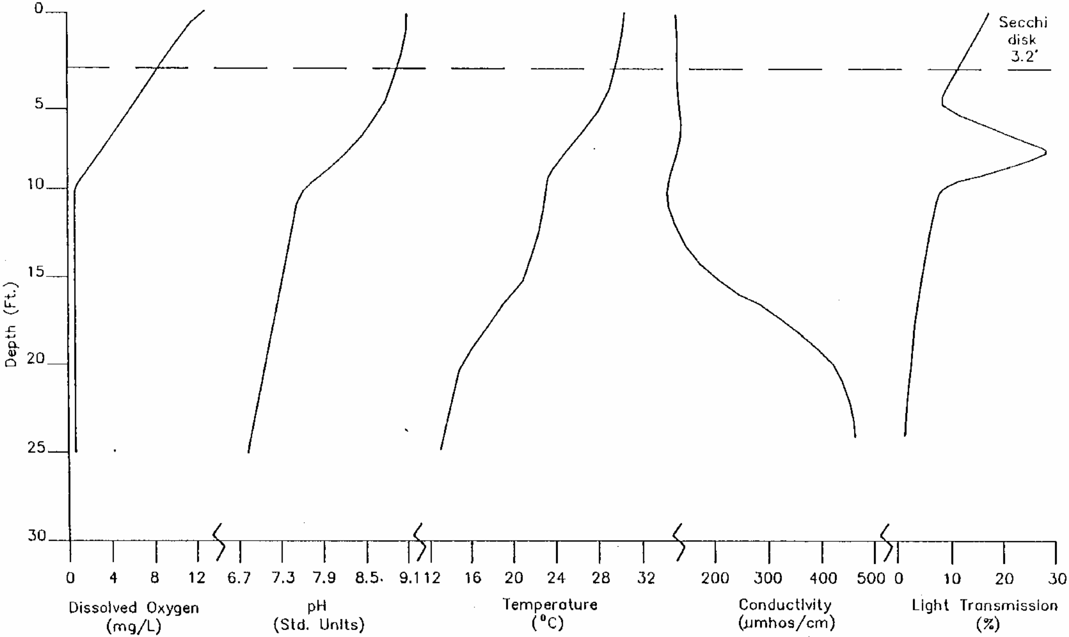

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FIGURE 3.
Selected Water Quality Parameters vs. Sampling Depth at Lake Salinda, Station LS3.

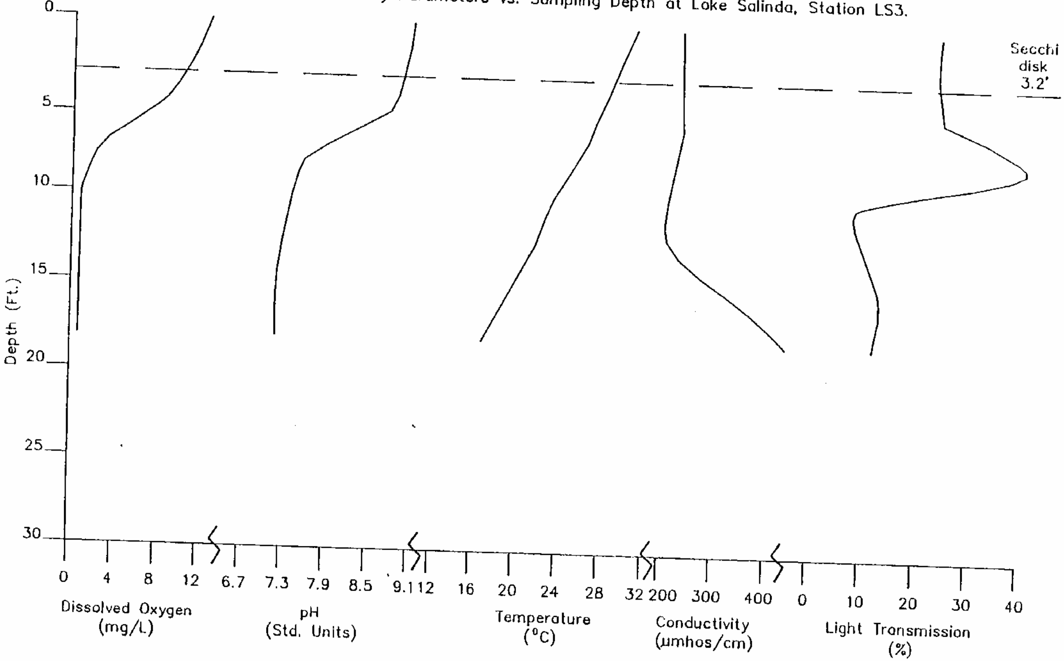

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FIGURE 4.
Selected Water Quality Parameters vs. Sampling Depth at Lake Salinda, Station LS4.

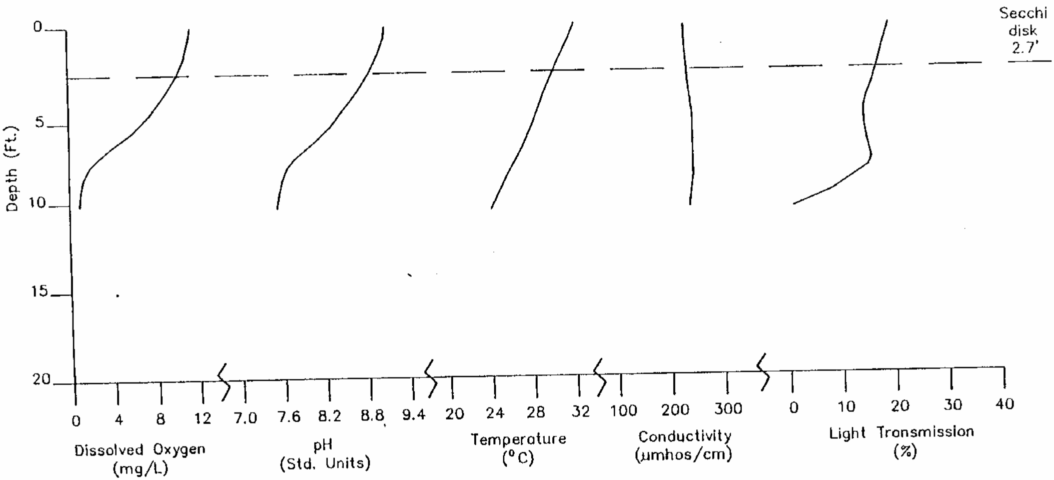

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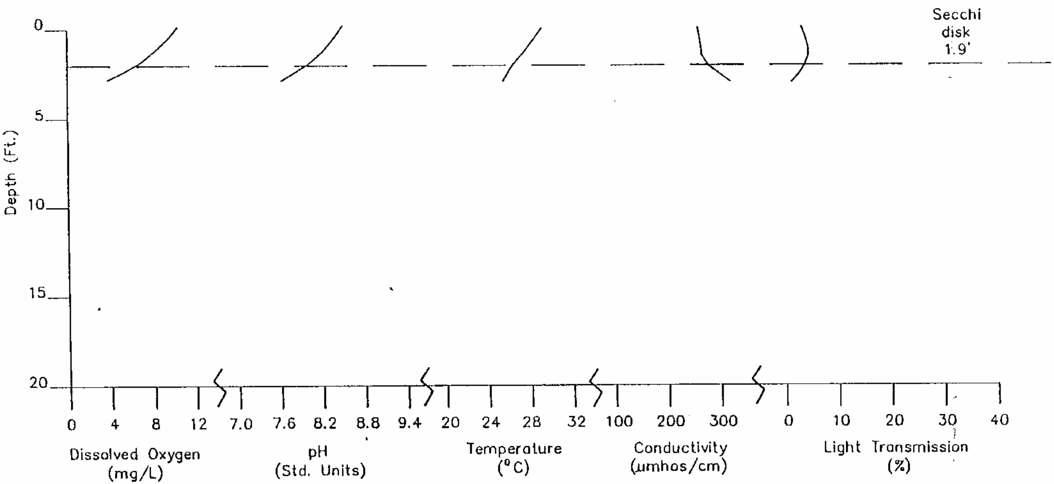
FIGURE 5.
Selected Water Quality Parameters vs. Sampling Depth at Lake Salinda, Station LS5.



2.2 Eutrophication Index

Various criteria have been used for lake classification. In this report, the lake trophic state is estimated by using a composite index used by the Indiana Department of Environmental Management (IDEM), developed by Harold Bonhomme. Points are assigned for lake trophic parameters generating scores ranging from 0 to 75, with 0 the least eutrophic (highest quality) and 75 being the most eutrophic (lowest water quality).

The IDEM publication, Indiana Lake Classification System and Management Plan (1986), lists Lake Salinda as having a Eutrophication Index of 63 and a rating of Class III. A second Eutrophication Index of 31 was also given. Donan Engineering contacted Mr. John Winters at IDEM and inquired into the trophic class and the double reading on three sets of data in this publication. Mr. Winters informed us that the double numbers were taken from two separate sampling periods. The higher eutrophication reading was following a major storm event. Not knowing which case study was accurate, they listed both sets of data and accepted the worst case for the trophic class designation. Our data from this study affirms that the lower eutrophication number of 31 was more reflective of the lake's eutrophic condition.

The IDEM Eutrophication Index was computed for Lake Salinda from the field and laboratory data collected at Station LS2 on August 4, 1988. Table 4 summarizes eutrophy point calculations for each of 10 diagnostic parameters. The results indicated a eutrophication index value of 41, which means the condition of the lake is progressively deteriorating based on the earlier value of 31.

Based on the broad classification division of the Index, as shown in Table 5, Lake Salinda can be classified as Class II, a eutrophic lake with intermediate water quality. A further description of characteristics commonly exhibited in Class II lakes is shown in Table 6. These common Class II characteristics closely describe the properties evidenced during our studies at Lake Salinda.

TABLE 4. ISBH LAKE EUTROPHICATION INDEX
LAKE SALINDA - AUGUST 4 1989
COMPOSITE OF STATION LS2

Parameter and Range		Range Observed	Eutrophy Points
I.	Total Phosphorus (ppm)		
	A. At least 0.03		1
	B. 0.04 to 0.05		2
	C. 0.06 to 0.19	0.11	>3<
	D. 0.2 to 0.99		4
	E. 1.0 or more		5
II.	Soluble Phosphorus (ppm)		
	A. At least 0.03	<0.01	1
	B. 0.04 to 0.05		2
	C. 0.06 to 0.19		3
	D. 0.2 to 0.99		4
	E. 1.0 or more		5
III.	Organic Nitrogen (ppm)		
	A. At least 0.5		1
	B. 0.6 to 0.8		2
	C. 0.9 to 1.9	1.42	>3<
	D. 2.0 or more		4
IV.	Nitrate (ppm)		
	A. At least 0.3		1
	B. 0.4 to 0.8	0.50	>2<
	C. 0.9 to 1.9		3
	D. 2.0 or more		4
V.	Ammonia (ppm)		
	A. At least 0.3		1
	B. 0.4 to 0.5		2
	C. 0.6 to 0.9	0.86	>3<
	D. 1.0 or more		4
VI.	Dissolved Oxygen (Percent Saturation at 5 ft. from surface)		
	A. 114% or less	79%	>0<
	B. 115% to 119%		1
	C. 120% to 129%		2
	D. 130% to 149%		3
	E. 150% or more		4
VII.	Dissolved Oxygen (Percent of water column with D.O. $\geq$ 0.1 ppm)		
	A. 28% or less		4
	B. 29% to 49%		3
	C. 50% to 65%		2
	D. 66% to 75%		1
	E. 76% to 100%	100%	>0<

TABLE 4. ISBH LAKE EUTROPHICATION INDEX (CON'T.)
LAKE SALINDA - AUGUST 4, 1989

Parameter and Range	Range Observed	Eutrophy Points
VIII. Light Penetration		
Secchi Disc		
A. Five feet or under	3.2 ft.	>6<
IX. Light Transmission		
(Percent at 3 ft.)		
A. 0 to 30%	15%	>4<
B. 31% to 50%		3
C. 51% to 70%		2
D. 71% and up		0
X. Total Plankton per ml:		
(Vertical tow from 5 ft. to surface)		
A. Less than 500 ml		0
B. 500 to 1,000/ml		1
C. 1,000 to 2,000/ml		2
D. 2,000 to 3,000/ml		3
E. 3,000 to 6,000/ml		4
F. 6,000 to 10,000/ml		5
G. More than 10,000/ml	10,000+	>10<
H. Blue-green dominance		5 additional points
(Vertical tow of 5 ft. through thermocline)		
A. Less than 1,000/ml		0
B. 1,000 to 2,000/ml		1
C. 2,000 to 5,000/ml		2
D. 5,000 to 10,000/ml		3
E. 10,000 to 20,000/ml		4
F. 20,000 to 30,000/ml		5
G. 30,000 or more	30,000+	>10<
H. Blue-green dominance		5 additional points
I. Populations of 100,000 or more		5 additional points

EUTROPHICATION INDEX	41

TABLE 5.

CLASSES OF LAKES BY TROPHIC STATUS
IDEM LAKE EUTROPHICATION INDEX
LAKE SALINDA

CLASS	EUTROPHY POINTS	DESCRIPTION
I	0 - 25	Least eutrophic lakes, highest quality.
II	26 - 50	Intermediate level eutrophic lakes, intermediate quality.
III	51 - 75	Advanced eutrophic lakes, lowest water quality.

TABLE 6

COMMONLY EXHIBITED CLASS II CHARACTERISTICS
LAKE SALINDA

* Total P concentrations of 0.04 to 0.06 mg/L as a water column average.

* TKN values of 0.6 to 0.9 mg/L as a water column average.

* Dissolved oxygen values are usually at 0.0 mg/L in the deeper waters of the hypolimnion during stratification.

* Plankton blooms occur frequently during hot weather but these are not commonly of nuisance proportions. Blue-green species are commonly dominant, but often alternate with diatoms.

* There are usually extensive, but non-problem, macrophyte concentrations in bays and littoral areas. Man-made channels and boat lanes usually have some degree of problems with the overproduction of macrophytes and/or algae.

* Solar light values at a depth of three feet usually range from 30 to 50 percent of surface value.

2.3 Non-Point Source Loading

A storm event of 1.7 inches during a 6-hour period was monitored and samples were collected from six inlet stations to evaluate the non-point source loading. Non-point loading typically only occurs during a storm event which produces watershed runoff. In watersheds where considerable amounts of agricultural activity occurs, non-point sources can be significant. Agricultural fertilizers, high in nitrogen and phosphorus, are easily transported by storm-event runoff into streams and water impoundments. The drainage area of Lake Salinda is predominantly rolling agricultural cropland, pasture, and forest. In Lake Salinda's watershed, a significant amount of the drainage area (76 percent) has an agricultural land base of cropland and pasture. Runoff from these areas is of particular concern. The results from our storm event sampling of Lake Salinda's inlets indicated this phenomenon as presented in Table 7.

The samples showed significant amounts of nitrogen and phosphorus entering the lake. Of particular significance are Stations LSR5 and LSR7 representing subwatersheds 5 and 6. Selected samples representing peak total suspended solids (TSS) from the storm hydrograph were analyzed. On-site and sample-specific laboratory analyses are presented in the Appendix. Suspended solids entering Lake Salinda ranged from 92 mg/L to 988 mg/L. Specific conductance ranged from 107 to 210 umhos/cm. High concentrations of nitrate and phosphorus were found at each storm sampling station. The inorganic nitrogen content, an important component of aquatic plant growth, was high in the storm samples, varying from a high 2.38 mg/L to an excessive 7.91 mg/L. Dissolved phosphorus was high, ranging from 0.13 to 0.56 mg/L. Dissolved phosphorus content of 0.01 mg/L or less is necessary to limit and minimize aquatic plant growth. The high nutrient content evidenced is directly attributable to agricultural runoff which is the primarily contributor to Lake Salinda's nutrient loading. Cropland comprises a significant percentage of the land usage of the lake watershed.

TABLE 7.
STORM EVENT ANALYSIS
LAKE SALINDA

STATION (SUBWATERSHED)	pH (s.u.)	DISSOLVED OXYGEN (mg/L)	SPECIFIC CONDUCTANCE (micromhos/cm)	TOTAL SUSPENDED SOLIDS (mg/L)	AMMONIA NITROGEN (mg/L as N)	TOTAL KJELDAHL NITROGEN (mg/L as N)	NITRATE NITROGEN (mg/L as N)	TOTAL PHOSPHORUS (mg/L)	DISSOLVED PHOSPHORUS (mg/L)
LSR1 (2)	7.5	7.9	170	168	0.08	2.05	3.18	0.55	0.33
LSR2 (3)	7.2	7.6	107	444	0.10	2.30	2.38	0.55	0.13
LSR3 (4)	7.2	7.0	144	488	0.31	2.50	3.54	0.77	0.31
LSR5 (5)	7.3	7.9	210	988	0.05	10.2	7.91	1.71	0.51
LSR6 (pt.6)	7.2	7.8	193	92	0.09	1.28	4.62	0.49	0.35
LSR7 (pt.6)	7.0	7.6	208	972	0.46	7.00	7.13	1.48	0.56
AVG	7.2	7.6	172	525	0.18	4.22	4.79	0.93	0.36
MIN	7.0	7.0	107	92	0.05	1.28	2.38	0.49	0.13
MAX	7.5	7.9	210	988	0.46	10.20	7.91	1.71	0.56

These influent nutrient levels are considerably different from the pool nutrient levels discussed earlier in this report. It is suspected that consistently high concentrations of limiting nutrients enter the lake during storms. Aquatic plants and algae have absorbed the available nutrients for growth, with the severity of the subsequent algal blooms dependent upon other conditions such as temperature, population cycles, residence time in the pool, and copper sulfate treatments.

2.4 Point Source Loading

The point source loading was evaluated at low-flow conditions. During low-flow conditions, non-point source nutrients from storm events do not enter the lake. By analyzing the nutrient content of inflow during low flow conditions, an evaluation of point source contributions can be made. The sources of point source contributions can include wastewater treatment plants, feedlots, etc.

The low flow analysis made at Lake Salinda indicated that these contributions were minimal, if any. During low flow conditions, tributaries were field checked for point source contributions. None of the tributaries were observed to flow during typical dry periods.

Our conclusions from field observations were that nutrient loading to the lake via point-source contributions was insignificant and that most nutrients entering the lake are attributed to non-point, agricultural sources.

2.5 Watershed Data

An analysis of the Lake Salinda watershed was made using U.S.G.S. topographic mapping and aerial photography. The photography was verified by field inspection (fall of 1988) and was analyzed according to land uses and subwatershed acreage. An Aerial/Watershed Land Use Map is enclosed in the Appendix. A soils map was prepared from the S.C.S., Soil Survey of Washington County, Indiana, and is included in the Appendix. An analysis of highly erodible land (HEL) was also made. This information was obtained from Mr. David Walton, the former

Erosion Control Technician, and Mr. David Elgin, District Conservationist for Washington County, Indiana. In Table 8, a summary of the watershed land use analysis is presented. The subwatershed divisions referred to in Table 8 are shown on the maps in the Appendix. The analysis shows the Lake Salinda watershed is 44 percent cropland and 32 percent pasture. Forest comprises 13 percent, and residential land uses comprise 8 percent of the total watershed.

A further analysis of these land uses as they relate to each influent monitoring point has been examined. The six influent points (LSR1-7) combine to account for 97 percent of all runoff entering the lake (Figure 1). Table 9 summarizes the land use categories for each influent point. The analysis shows that cropland and pasture combine to constitute a significant portion of the land area (74 percent) monitored by the influent points.

Of the soils within the Lake Salinda watershed, 80.2 percent are classified as highly erodible land (HEL). The HEL areas comprised 91.3 percent of the subwatersheds monitored at the six influent stations. Table 10 lists the data by subwatershed and for the total watershed.

Using SCS methodology, the weighted curve number (CN) for the entire watershed was computed to be 68 accounting for the various land uses. Curve numbers are used to classify soil and cover in the watershed. A CN of 100 indicates very little cover and high runoff rates; a CN of 25 would indicate good cover and low runoff rates. A CN of 68 is a mid-range value.

TABLE 8.
WATERSHED LAND USE ANALYSIS IN ACRES

WATERSHED SECTION	FOREST	CROPLAND	PASTURE	RESIDENTIAL	WATER	ROAD	INDUST.	TOTAL
LSW-1	22.3	17.3	31.1	--	--	--	--	70.7
LSW-2	30.3	52.1	115.1	5.2	0.4	4.4	--	207.5
LSW-3	120.3	312.1	301.1	37.6	4.9	13.7	--	789.7
LSW-4	260.9	935.8	508.1	217.6	4.1	46.1	19.4	1992.0
LSW-5	18.9	132.7	98.4	7.8	0.2	5.7	--	263.7
LSW-6	--	37.5	51.8	--	--	--	--	89.3
TOTAL	452.7	1487.5	1105.6	268.2	9.6	69.9	19.4	3412.9
PERCENT	13.2%	43.6%	32.4%	7.9%	0.3%	2.0%	0.6%	100%

TABLE 9.

MONITORED SUBWATERSHED LAND USE ANALYSIS IN ACRES

INFLUENT MONITORING POINT	WATERSHED SECTION	FOREST	CROPLAND	PASTURE	OTHER	TOTAL
LSR1	LSW-02	30.3	52.1	115.1	10.0	207.5
LSR2	LSW-03	120.3	312.1	301.1	56.2	789.7
LSR3	LSW-04	260.9	935.8	508.1	287.2	1992.0
LSR5	pt. LSW-5	18.9	132.7	78.1	13.7	243.4
LSR6	pt. LSW-6	0.0	2.1	28.4	0.0	30.5
LSR7	pt. LSW-6	0.0	35.4	21.5	0.0	56.9
TOTAL		430.4	1470.2	1052.3	367.1	3320.0
PERCENT		12.6%	43.1%	30.8%	10.8%	97.3%

TABLE 10.

HIGHLY ERODIBLE LAND (HEL) ANALYSIS

INFLUENT MONITORING POINT	WATERSHED SECTION	NON-HEL (ACRES)	SUBWATERSHED (ACRES)	PERCENT NON-HEL	PERCENT HEL
LSR1	LSW-02	1.7	207.8	0.8	99.2
LSR2	LSW-03	135.1	789.7	17.1	82.9
LSR3	LSW-04	518.5	1992.0	26.0	74.0
LSR5	pt. LSW-5	20.1	243.4	8.3	91.7
LSR6	pt. LSW-6	0.0	30.5	0.0	100.0
LSR7	pt. LSW-6	0.0	56.9	0.0	100.0
		675.4	3320.3	8.7%	91.3%
TOTAL WATERSHED		675.6	3412.9	19.8%	80.2%

2.6 Sediment Data

During the site visit on August 4, 1988, the larger inlets into the lake were sounded in order to construct a profile and contour map of each inlet. These maps were to be compared to the topographic maps made before the lake was impounded. However, there are no known topographic maps of the lake prior to construction having contacted several state and federal agencies in an attempt to locate such a map. As a result, the actual volume of sediment in the inlets could not be calculated, but estimates could be made. To increase the water depth to 8 feet at the inlet of LSW-3 approximately 31,600 cu. yd. of sediment would have to be removed. To increase the water depth to 8 feet at the inlet of LSW-4, approximately 180,500 cu. yd. of sediment would require removal.

A significant amount of sediment occurs at all the inlets of Lake Salinda, particularly LSW-3, and LSW-4 as previously shown. Sediment deltas have formed in the lake inlets and have made boating in these areas difficult. The deltas extend outward into the lake for several hundred feet and form shallow areas 1 to 3 feet deep. Most of the sediment coming into the lake appears to be transported from the cropland areas upstream of the lake. At the inlets of LSW-3 and LSW-4, it is estimated that over 7 acres of lake surface area has been totally silted in and is now vegetated.

On August 4, 1988, sediment core samples were collected at four sites, LSS1, LSS2, LSS4, and LSS5. These sites, shown in Figure 1, are located in sediment deltas in four of the lake's inlets. The samples were composited from columns of sediment collected to a 24-inch depth. Each core was analyzed for the parameters listed in Table 2. In Table 11, the results from those determinations are summarized. The laboratory data sheets are included in the Appendix.

Values of total phosphorus ranged from 54.4 mg/Kg to 343 mg/Kg in the four sediment samples. Plant available phosphorus concentrations were also determined and were at minimum detection limits in three of the four samples analyzed. The concentration of available phosphorus at station LSS5 was 93 pounds per acre which is considered high. Total kjeldahl nitrogen (TKN) was very high in the samples at 800 mg/Kg or greater. Nitrate and ammonia concentrations were also high. A high ammonia value of 63.0 mg/Kg was determined in the sample from station LSS1. All four watersheds contain a significant amount of agricultural land usage. Runoff from these fertilized lands have contributed significantly to the nutrient rich sediment in Lake Salinda.

TABLE 11.

ANALYSIS OF SEDIMENT CORE SAMPLES

LAKE SALINDA INLETS

SITE ID	WATERSHED SECTION	TOTAL PHOSPHORUS	TOTAL KJELDAHL NITROGEN	AMMONIA NITROGEN	NITRATE NITROGEN	AVAILABLE PHOSPHORUS (lbs/acre)
		---	(mg/Kg)	---	---*---	
LSS1	LSW-2	54.4	1000	63.0	<3.70	<5
LSS2	LSW-3	72.1	900	1.60	<2.15	<5
LSS4	LSW-4	104	800	0.80	<2.31	<5
LSS5	LSW-5	343	1000	1.00	<6.94	93

* Below detection limits based on different dilutions utilized as stated by the water quality lab.

2.7 Storm Event Model

To predict storm event sediment loading into Lake Salinda, the Agricultural Non-Point Source Pollution Model (AGNPS) was used, developed by the Minnesota Pollution Control Agency, the Minnesota Soil and Water Conservation Board, and the U.S. Soil Conservation Service. The model was designed "to obtain accurate estimates of runoff quality with primary emphasis on sediment and nutrients" from agricultural watersheds. Input parameters include the following: land slope, land shape, field slope length, channel slope, roughness coefficient, soil erodibility factor, cropping factor, practice factor, surface condition constant, aspect, soil texture, fertilization level and availability, and point source indicators. Several of the input variables were developed for the Universal Soil Loss Equation (USLE).

To manipulate the data to the conditions existing at Lake Salinda, the monitored rainfall event of 1.7 inches/6 hours was used. The land use and mapping characteristics described in the previous sections were also used. The modeling results are presented for five subwatersheds in Table 12. A theoretical 4.6-inch/10-year/24-hour storm event was also modeled. As shown in Table 12, the AGNPS Model estimates total soluble nitrogen and phosphorus in the runoff. The 10-year/24-hour storm modeling results show that 481 tons of sediment would be delivered to Lake Salinda in such a storm event, with critical subwatersheds being LSW3, LSW4 and LSW5. Manipulation of the modeled conditions was not conducted due to budget restrictions and on-going revisions to the AGNPS model.

2.8 Aquatic Weed Survey

On August 4, 1988, an aquatic weed survey was made of the lake. Emergent plants along the shoreline, as well as submergent plants, were identified. The summary presented in Table 13 lists the predominant aquatic weeds found. Most of these aquatic weeds were located in a 10 to 20-foot band around the lake shoreline. Some of the weeds, especially the cattails, torpedo grass, and American pondweed, are a nuisance

TABLE 12. SUMMARY OF AGRICULTURAL NON-POINT SOURCE POLLUTION MODEL (AGNPS) AND ACTUAL STORM DATA COLLECTED AT LAKE SALINDA

			ACTUAL STORM[1]				ACTUAL STORM MODELED				10-YR, 24-HR STORM MODELED				
WATERSHED SECTION	ACRES	AVERAGE CN	PEAK Q (CFS)	TSS (mg/L)	TOT N (mg/L)	TOT P (mg/L)	PEAK Q (CFS)	TSS[2] (mg/L)	TOT N[3] (mg/L)	TOT P[3] (mg/L)	PEAK Q (CFS)	TSS (mg/L)	TOT N (mg/L)	TOT P (mg/L)	SEDIMENT (TONS)
LSW2	208	65	18	168	5.23	0.55	24	224	6.3	1.1	261	135	1.58	0.22	17
LSW3	790	68	48	444	5.68	0.55	48	404	9.6	1.8	450	271	2.34	0.39	101
LSW4	2000	67	140	488	6.04	0.77	104	382	5.1	0.9	1033	274	1.50	0.20	234
LSW5	243	76	35	988	18.11	1.71	39	714	8.0	1.5	274	546	2.40	0.40	103
LSW6	87	67	30	972	14.13	1.43	33	718	8.8	1.7	191	345	2.20	0.30	26
															481

1 Data from monitored storm event - 1.7 inches/6 hours, July 20-21, 1988.

2 Mean concentration of clay and silt material.

3 Nutrients are total soluble nutrients in runoff.

to fishermen and boaters. Photographic documentation is provided in the Appendix. These photographs show the extent of the aquatic weed growth, as well as identify areas where there are no significant weeds present.

The results of the survey identified the predominant aquatic weeds, which are common weeds in most lakes in this region. Their location around the lake seemed to be mainly associated with shallow areas where siltation has occurred. Some minor weed growth was observed in water depths up to 8 feet at certain points along the lakeshore.

A review was made of aquatic weed survey data from a 1979 Fish Management Report by Larry L. Lehman, Division of Fish and Wildlife. Naiads (Najas minor, Najas guadalupensis, Najas gracillima) and pondweeds (Potamogeton nodosis, Potamogeton pectinatus) were identified in 1979 as nuisance aquatic plants in shallow areas of the lake.

Efforts to control the aquatic plant problem at Lake Salinda have been limited to copper sulfate to control algae populations. Physical measures, such as pool drawdown or mechanical removal, have not been utilized at Lake Salinda thus far.

Copper sulfate is applied during the summer season to control algae. It was reported that 500 pounds per year was the typical rate of copper sulfate applied. The results of the algicide program are reported have been marginally effective. At the application rate used, it appears that the copper sulfate has temporarily reduced algal blooms, but obviously has not eliminated the source of the problem.

In terms of algae, two algal tows were conducted at the deepest lake site, LS2: a 5-foot to surface tow, and a tow 5 feet through the beginning of the thermocline. In Table 14, the identification of the predominant species is presented. A diverse variety in algal populations is evident, however, of the 9 species identified, 5 are noted as taste and odor causing algae.

TABLE 13.

AQUATIC WEED SUMMARY
LAKE SALINDA

AUGUST 4, 1988

PLANT TYPE	COMMON NAME	SCIENTIFIC NAME	DEPTH (ft.)	PERCENT COVER[1]
Submergent	American pondweed	Potomogeton nodosus	0-3	5
Emergent	Cattail	Typha sp.	0-1	5
	Torpedograss	Panacum repens	0-1	5
Floating	Duckweed	Lemna minor	N/A	15

[1] Coverage refers to surface area for submergent and floating plants and shoreline length for emergent plants.

TABLE 14.

SUMMARY OF ALGAE IDENTIFICATION

ALGAL TYPE	SAMPLE TOW	
	0-5 FEET	THERMOCLINE
Blue-green Algae		
*Anabaena sp.	X	
Green Algae		
Cosmarium sp.	X	
Netrium deigitus	X	
*Pediastrum sp.		X
*Scenedesmus quadricauda	X	
*Starastrum sp.	X	
Filamentous Green Algae		
Cladophora sp.	X	
Flagellate Algae		
*Chlamydomonas sp.	X	
Gonium pectorale	X	
Population Counts	10,000+	30,000+

* Noted as taste and odor causing algae (Palmer, 1964).

SECTION 3. IDENTIFICATION OF PROBLEMS

A broad base of data is important in identifying problem areas in a given watershed. In this study, the water quality, sedimentation, and aquatic weed data were used to characterize the Lake Salinda watershed. An accurate assessment of these characteristics is essential to make prudent management decisions.

The lake water quality data indicated good quality. The lake phosphorus and nitrogen concentrations were low. The lake transparency was very good and no significant point source nutrient contributions were identified. The influent water quality, however, was very poor. Suspended sediments averaged 525 mg/L as an average, with average nutrient levels moderately high to excessive. Of specific note are the nitrate concentrations at all monitored influent points. The excessive amount of nutrients washing into the lake during storms is providing for the enrichment of the lake sediments and proliferation of algae and aquatic weed populations, as well as deteriorating the water quality of the lake.

The sediment loading to the lake is another one of the major problems occurring. Deltas of nutrient-rich silt in several inlets are reducing the lake volume, promoting weed growth, and reducing navigable areas on the lake. Current land management practices, tillage methods, and fertilizing techniques on predominately highly erodible land are providing for excessive sediment and nutrient loading to the lake which accelerates the eutrophication process.

A future problem will be unrestricted development of the lake watershed. It is recommended prior to any residential development that a soil survey be conducted by a soil scientist and engineer for professional recommendations on waste disposal systems. Due to land slope and soil characteristics such as depth to bedrock, fragipans, and permeability, conventional septic tank systems may not be suitable. Other types of systems such as elevated sand mounds, shallow trench systems and pressure distribution systems may be applicable on a site specific basis. Any septic system by design must eventually saturate the soil of the septic field into which the wastewater is discharged. This effluent from septic systems will not only originate from excreta and ground garbage, but also laundry and other cleaning wastes, which will contribute nitrogen, phosphorous and bacteria to the lake. This creates the situation where the sewage saturates the groundwater causing a diffuse discharge of nutrients from the shore into the lake (IDEM, 1986). Implementation of Indiana State Board of Health Rule 410, IAC 6-8, concerning residential sewage disposal system permits by state personnel and the county sanitarian, will provide for suitable waste management systems on a site specific basis.

SECTION 4. RESTORATION ALTERNATIVES

As identified in the previous sections, reduction of agricultural sediment and nutrient loading, and control of aquatic vegetation are the major current problems to be addressed by the lake management. In this section, several alternative solutions are presented to respond to these problems and to enhance the quality of the lake. Along with each alternative, the expected results of each are discussed.

4.1 Maintain Current Management

By selecting this alternative, no efforts would be made to control sediment, but the chemical methods currently being used to control algal populations would continue.

The chemical control methods currently include an early summer application of copper sulfate. The present chemical management program would, at best, temporarily limit proliferation of algal growth, but would not respond to the source of the problem. Disadvantages of perpetually continuing the use of copper sulfate include the potential acute toxic effect on other aquatic organisms, the disruption of the balance in existing aquatic life, and the possible unrestricted dominance of a single kind of algae (Palmer, 1964), as well as contributing to dissolved oxygen depletion, increased internal nutrient cycling, and copper accumulation in the lake sediments (EPA, 1988).

As mentioned earlier, this alternative does not address the aquatic plant problem or the sediment problem. Without sediment control, siltation of the lake will continue to load more sediment and nutrients. More shallow areas will form and boat navigation in the lake will be continually reduced. Eutrophication is expected to continue at an advanced rate, with the eventual outcome being the senescence of the lake and the subsequent development of a wetland.

4.2 In-Lake Restoration

Based on the excessive sedimentation of the lake and its inlets, the nutrient concentration of the sediment, and the proliferation of aquatic plants, as well as the eutrophication value of the lake (41 points), to maintain the lake as a secondary potable water supply and recreational lake, restoration is a priority, but must be accompanied by reducing future nutrient inputs in order to achieve long-term improvement (IDEM, 1986).

Dredging of the lake is an alternative though dredging is expensive and the transportation, storage and/or disposal of the material is also costly. Dredging would require a Corps of Engineers permit, as well as a Construction in a Floodway permit from IDEM. However, selective dredging of the inlets at subwatersheds LWS-3 (31,600 cu. yd.) and LSW-4 (180,500 cu. yd.) may be an alternative providing for increased lake volume and removal of nutrient-rich sediments and associated aquatic weeds. Costs for dredging can range from $2.00 to $5.00 per cubic yard, with additional variable costs of hauling and disposal. The immense quantity of sediment that would require removal, geologic conditions in the area, and the associated factors concerning dredging equipment, hauling distance and disposal site would necessitate a dredging feasibility study to determine if the benefits would justify the expense. Currently, there are no available grants for dredging from the Division of Soil Conservation.

An alternative to dredging to increase lake volume is the consolidation of the lake sediments by drawdown. The water content of organic-rich sediments in eutrophic lakes frequently exceeds 90% by volume (IDEM, 1986). By drawing down the lake five feet during the late fall or early winter, a considerable quantity of accumulated sediments at the lake inlets would consolidate and stabilize by desiccation. However, it should be noted that productivity may temporarily increase due to accelerated microbial conversion of organic nutrients to plant-available inorganic forms, and certain aquatic plant species, namely cattail (<u>Typha latifolia</u>), can be expected to increase with drawdown (Cooke, 1986).

To mitigate this circumstance and respond to phosphorus concentrations assumed to be present in the lake in early spring prior to green-up, an aluminum sulfate (alum) or sodium aluminate treatment could be a second-phase treatment after drawdown. Alum would either be sprayed on the surface or injected underwater by a boat or barge. It almost instantly would form a gelatinous precipitate removing suspended solids and dissolved phosphorus as it descends through the water column, and would suppress the release of phosphorus from sediments of the lake bottom. However, lake morphology, climatic conditions and thermal structure will have significant effects on this kind of treatment, its applicability and the associated cost. If successful, this kind of treatment can be effective for many years provided phosphorus loading to the lake is greatly decreased. The cost could be expected to run from $400 to $1000 per acre treated ($13,000 to $30,000).

A response to the problem of excessive aquatic plant growth is to actively manage the plants by harvesting them. Most species of submergent and emergent aquatic weeds can be removed in front of boat docks or around the lake shore by lake managers using hand held weed harvesters ranging in price from $100 to $300 (Appendix). For excessive beds of aquatic plants in the lake, mechanical harvesters are available, can be competitive in price to annual aquatic herbicide applications, and are an alternative when herbicides are restricted on potable water supply reservoirs. These mechanical harvesters are initially expensive at $30,000 to $50,000 (Appendix). However, harvesters may be available to rent from other lake owners, or harvesting services may be provided by contractors in the lake management business.

Chemical treatments consisting of aquatic herbicide application may not be an alternative at this time due to restrictions on the use of herbicides on potable water supplies, and the distance from the reservoir to the principle intake structure at the water utility. Future advances in chemical compounds, treatment methods and/or reservoir usage may alter this situation, and permit their application in specific circumstances. Should this ever become the case, caution should be made for the application of these herbicides by a licensed pesticide applicator familiar with aquatic plant management. Herbicides are species specific, so detailed plant identification and selection of suitable herbicides would be necessary. It would also be desirable and necessary that some aquatic plants be maintained in coves and inlets to provide for fish habitat areas as advised by Division of Fish and Wildlife personnel, as well as for the natural filtering of sediments and nutrients that aquatic vegetation provides.

This treatment, much like the copper sulfate treatments that are currently utilized to manipulate the algae populations, would be only temporary, does not remove the nutrients contained in the plant tissue, and does not respond to the significant source of the nutrient loading. The long-term effects of these chemicals have been associated with major adverse impacts on lake systems and are not "restorative". These adverse impacts include: nutrient release to the water following plant death; dissolved oxygen depletion following plant decay; toxic effects on non-target aquatic organisms at recommended doses; and rapid regrowth of plants following treatment (Cooke, 1986).

4.3 Watershed Management

The long-term quality and restoration of Lake Salinda will primarily concentrate on the prompt and comprehensive implementation of Best Management Practices (BMPs) on the predominantly agricultural watershed, employing T by 2000 objectives of the state, IDNR, Division of Soil Conservation, and federal, USDA, Soil Conservation Service. These BMPs would be evaluated, designed and implemented by the professional staff of the SCS and the IDNR, Erosion Control Technician. Agricultural BMPs would involve conservation tillage, contour farming, contour stripcropping, pasture management, crop rotation, terraces, livestock exclusion, animal waste management, and fertilizer management. The predominance of highly erodible soils, current cropping methods, and extent of agricultural acreage, are combining to be the primary source of sediment and nutrient loading to Lake Salinda.

In addition to agricultural BMPs, residential BMPs are also desirable, including streamside management zones, grassed waterways, and streambank stabilization. Another residential management method is a septic tank maintenance program providing for the proper functioning of septic systems on the watershed to minimize nutrient and bacteria loading to the lake.

A final method is the implementation of zoning and development regulation to provide for the regulation of project density, waste treatment systems, and shoreline protection.

SECTION 5. PREFERRED ALTERNATIVE

The preferred alternative for Lake Salinda must respond to the principle source of the sediment and nutrient loading to provide for the long-term quality of the lake, while addressing the consequences of the excessive sediment and nutrient loading. The preferred alternative presented takes into consideration not only the current trophic status of the lake, but also the restoration alternatives that are practicable under the cumulative circumstance.

The primary response to the sedimentation and nutrient loading, which has resulted in excessive algae and aquatic weed production, significant loss of lake surface area and volume, and impaired recreational use of the lake, is the implementation of T by 2000 land treatment practices on the watershed of Lake Salinda. Soil conservation technicians and erosion control specialists should contact pertinent agricultural landowners to evaluate soil erosion problems on croplands and pasturelands. Appropriate and comprehensive conservation plans should be developed and implemented by various state and/or federal cost-share programs. Examples of numerous, potentially applicable programs are: Conservation Reserve Program, Agricultural Conservation Program, Long-Term Agreements, Long-Term Contracts, and the state's Cropland Erosion Control Program. Only by significantly reducing the sediment and nutrient loading originating from these agricultural subwatersheds will any restoration technique be feasible for Lake Salinda.

A second response, only after land treatments have been effectively implemented, is a two-phase treatment of lake drawdown and alum treatment. It is recommended that the lake level be dropped five feet during the early winter to expose significant sediment deltas in the principle inlets to desiccation, thereby decreasing sediment volume and stabilizing the surface sediment layers. The following spring, a one-time alum treatment would be conducted while phosphorous is present at peak levels in the lake pool. However, this second phase of alum treatment will be a short-term, temporary treatment rather than last for many years if phosphorus loading from the watershed is not significantly reduced. The alum treatment would require additional laboratory and on-site tests to determine applicability, expected results, and quantity of chemicals necessary. Costs would be variable based on the treatment area of the hypolimnion (cool, bottom water), the quantity of chemicals required, the availability of equipment and the associated costs of labor (Appendix).

The current algal problems affecting the lake and the potable water quality will be immediately managed only by the continued application of copper sulfate. A long-term, significant decrease in the algal populations and their detrimental effects will only be seen as nutrient loading to the lake significantly decreases by land treatment methods.

The remaining recommendation is the implementation of zoning and development regulations on both the primary and secondary water supply reservoirs for the City of Salem. Zoning and development regulations would provide for the control of residential and commercial project density, associated waste treatment systems, as well as stream and shoreline protection. A long-term supply of potable water in sufficient quantity can only be insured by comprehensive, consistent management of a lake and its watershed with a foundation in city ordinances and regulations.

REFERENCES

Cooke, G.D. 1986. Lake and Reservoir Restoration. Butterworth Publishers, 392 pp.

Indiana Department of Environmental Management. 1986. Indiana Lake Classification System and Management Plan, 12 pp.

Indiana Department of Natural Resources, Division of Fish and Wildlife. Lake Salinda Fish Management Reports. 1979.

Palmer, C.M. 1964. Algae in Water Supplies of the United States. Algae and Man. New York, Plenum Press, pp. 239-261.

U.S. Environmental Protection Agency. 1988. The Lake and Reservoir Restoration Guidance Manual. Criteria and Standards Division, Nonpoint Sources Branch, U.S. Environ. Prot. Agency, Washington, D.C., EPA 440/5-88-002.

U.S.D.A. Soil Conservation Service. 1978. Soil Survey of Washington County, Indiana.

APPENDIX

FIELD DATA SHEETS

NASHVILLE DISTRICT

WATER QUALITY FIELD DATA

CORPS OF ENGINEERS

LOCATION: Lake Salinda 1 outfall

BY: EMT, JB, SY

WEATHER: Sunny

WIND VELOCITY: Calm

AIR TEMPERATURE: 85

COLOR:

CURRENT SPEED:

BAROMETER:

REMARKS: Not discharging from spillway, leaking @ 1 ft below crest of spillway ≃ 75 gal/min

STATION (1-9)	DATE (10-15)	TIME (16-19)
SALINDA 1	880304	1045

DUPLICATE COLUMNS 1-19 ON ALL CARDS

(Zero - fill columns 1 - 22)

DEP. (20-22)	TEMP. (23-26)	D.O. (27-30)	COND. (31-34)	PH (35-38)	ORP (39-42)	TOT. ALK. (43-45)	PHTH. ALK. (46-48)	MAX. DEP. (49-51)	DIST. BET. BANKS (52-55)	DIST. FROM L.BANK (56-59)	SECCHI DISK (60-63)	WATER SURFACE ELEVATION (64-69)	INST. DISCHARGE (70-75)	(76-80)
000	28.7	9.5	232	9.0										

ORN Form 561

ORNED F

NASHVILLE DISTRICT

WATER QUALITY FIELD DATA

CORPS OF ENGINEERS

LOCATION Lake Salinda 2 @ dam BY EMT, JB SY

WEATHER Sunny

WIND VELOCITY Calm AIR TEMPERATURE 90

COLOR LT Green-brown CURRENT SPEED ____ BAROMETER ____

REMARKS Station in Front of intake structure

STATION	DATE	TIME
1 2 3 4 5 6 7 8 9	10 11 12 13 14 15	16 17 18 19
Salinda2	880804	1130

DUPLICATE COLUMNS 1-19 ON ALL CARDS

(Zero-fill columns 1-22)

DEP.	TEMP.	D.O.	COND.	PH	ORP	TOT. ALK.	PHTH ALK.	MAX. DEP.	DIST. BET. BANKS	DIST. FROM L.BANK	SECCHI DISK	WATER SURFACE ELEVATION	INST. DISCHARGE	%/T
20 21 22	23 24 25 26	27 28 29 30	31 32 33 34	35 36 37 38	39 40 41 42	43 44 45	46 47 48	49 50 51	52 53 54 55	56 57 58 59	60 61 62 63	64 65 66 67 68 69	70 71 72 73 74 75	76 77 78 79 80
000	29.3	12.8	229	9.1				28			3.0			19
005	28.5	6.1	233	8.8										12
010	23.4	0.7	202	7.6										8
015	20.3	0.6	308	7.3										5
020	14.7	0.7	483	7.1										
025	12.1	0.7	558	6.8										0
119														0.3
7.5	25.1	1.9	205	7.7										28
2.5														8

NASHVILLE DISTRICT

WATER QUALITY FIELD DATA

CORPS OF ENGINEERS

LOCATION Lake Salinda NO 3 BY EMT, JG, SY

WEATHER Sunny

WIND VELOCITY Calm AIR TEMPERATURE 90

COLOR CURRENT SPEED BAROMETER

REMARKS in mid Lake across from dead Tree on Right Bank.
station is approximately 1800 ft upstream from dam.

STATION (1–9)	DATE (10–15)	TIME (16–19)
Salinda 3	880804	1200

DUPLICATE COLUMNS 1-19 ON ALL CARDS

(Zero-fill columns 1-22)

DEP. (20–22)	TEMP. (23–26)	D.O. (27–30)	COND. (31–34)	PH (35–38)	ORP (39–42)	TOT. ALK. (43–45)	PHTH. ALK. (46–48)	MAX. DEP. (49–51)	DIST. BET. BANKS (52–55)	DIST. FROM L.BANK (56–59)	SECCHI DISK (60–63)	WATER SURFACE ELEVATION (64–69)	INST. DISCHARGE (70–75)	%/T (76–80)
000	29.7	12.5	231	9.1							3.2			24
005	27.8	7.5	234	8.8										25
7.5	25.5	1.9	213	7.6										49
10	23.7	0.6	197	7.5										8
15	19.8	0.5	332	7.2										13
18	17.2	0.5	428	7.2										2

NASHVILLE DISTRICT

WATER QUALITY FIELD DATA

CORPS OF ENGINEERS

LOCATION: Lake Salinda NO 4 BY: EMT, JB, SY

WEATHER: Sunny

WIND VELOCITY: Calm AIR TEMPERATURE: 70's

COLOR: Brownish Green CURRENT SPEED: BAROMETER:

REMARKS: Accross From Ramp, approximately 4100 FT From dam.

STATION (1-9)	DATE (10-15)	TIME (16-19)
SALINDA 4	880804	1415

DUPLICATE COLUMNS 1-19 ON ALL CARDS

Above water %T 95

(Zero-fill columns 1-22)

DEP. (20-22)	TEMP. (23-26)	D.O. (27-30)	COND. (31-34)	PH (35-38)	ORP (39-42)	TOT. ALK. (43-45)	PHTH. ALK. (46-48)	MAX. DEP. (49-51)	DIST. BET. BANKS (52-55)	DIST. FROM L.BANK (56-59)	SECCHI DISK (60-63)	WATER SURFACE ELEVATION (64-69)	INST. DISCHARGE (70-75)	%T (76-80)
000	32.6	11.1	231	9.1							2.7			19
005	28.8	6.3	244	8.4										14
7.5	26.5	2.0	240	7.7										16
010	24.2	1.2	234	7.5										1
0														
2.5														15

NASHVILLE DISTRICT

WATER QUALITY FIELD DATA

CORPS OF ENGINEERS

LOCATION Lake Salinda NO 5 BY EMT, JG, SY

WEATHER Sunny

WIND VELOCITY Calm AIR TEMPERATURE 90's

COLOR Brown CURRENT SPEED BAROMETER

REMARKS up largest Tri's

(Zero - fill columns 1 - 22)

STATION	DATE	TIME
1-9	10-15	16-19
Salinda 5	880804	1245

DUPLICATE COLUMNS 1-19 ON ALL CARDS

DEP.	TEMP.	D.O.	COND.	PH	ORP	TOT. ALK.	PHTH. ALK.	MAX. DEP.	DIST. BET. BANKS	DIST. FROM L.BANK	SECCHI DISK	WATER SURFACE ELEVATION	INST. DISCHARGE	%/T
20-22	23-26	27-30	31-34	35-38	39-42	43-45	46-48	49-51	52-55	56-59	60-63	64-69	70-75	76-80
000	30.9	10.2	260	8.5				4			1.9			3
003	27.7	3.5	326	7.6										2
1.5	29.3	7.8	268	8.2										4

LAB DATA SHEETS

COMMONWEALTH TECHNOLOGY, INC.
2520 Regency Road, Suite 104
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606-276-3506

ARD G. FOREE, Ph.D., P.E.
JOHN S. TAPP, Ph.D., P.E.

Environmental and Natural Resources Consulting and Analytical Services

DATE: 9/6/88
*AMENDED 9/12/88

CTI REPORT NO: DO 8019

CTI LAB NO: See Below

CTI PROJECT NO: 188

TO: Jim Buckles

REPORT ON TESTING OF WATER SAMPLES

SOURCE OF SAMPLE: Lake Salinda 880804 (See Below)

DATE OF COLLECTION: 8/4/88

DATE RECEIVED: 8/5/88

SAMPLE TYPE: Grab

CTI LAB NO:	SAMPLE ID:	Total Suspended Solids (mg/L)	Nitrate-Nitrogen (mg/L as N)	Ammonia-Nitrogen (mg/L as N)	Total Kjeldahl Nitrogen (mg/L as N)
W8806524	No.5,1245, 0'-4'	12	<0.05	0.22	0.86
W8806525	No.2,1130, 0'	8	0.7*	0.06	1.85
W8806526	No.2,1130, 5'	8	0.8*	0.09	1.30
W8806527	No.4,1130, 0'-10' comp.	11	0.8*	0.21	1.40
W8806528	No.2,1130, 25'	16	<0.05	2.42	3.70
W8806529	No.1,1045, Outfall	8	0.8*	0.07	1.85
W8806530	No.3,1200, comp.	8	0.9*	0.38	1.24

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CTI LAB NO:	SAMPLE ID:	Phosphorus, Total (mg/L as P)	Phosphorus, Dissolved (mg/L as P)	Copper, Total (mg/L)
W8806524	No.5,1245, 0'-4'	0.11	<0.01	--
W8806525	No.2,1130, 0'	0.06	<0.01	--
W8806526	No.2,1130, 5'	0.06	<0.01	--
W8806527	No.4,1130, 0'-10' comp.	0.10	<0.01	--
W8806528	No.2,1130, 25'	0.22	0.01	0.61
W8806529	No.1,1045, Outfall	0.07	<0.01	--
W8806530	No.3,1200, comp.	0.13	0.01	--

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Environmental and Natural Resources Consulting and Analytical Services

DATE: August 8, 1988
*Amended: December 1, 1988
**Amended: February 27, 1989

CTI REPORT NO: DO 8011

CTI LAB NO: W8806284

PROJECT NO.: **188

TO: Jim Buckles

REPORT ON TESTING OF WATER SAMPLES

SOURCE OF SAMPLE: Donan/*Lake Salinda - LSR1 - 10:00 A.M.

DATE OF COLLECTION: *7/20-21/88

DATE RECEIVED: 7/22/88

SAMPLE TYPE: Grab

PARAMETER	CONCENTRATION
pH	7.5
Dissolved Oxygen (mg/L) (readings taken in lab 7/25)	7.9
Conductivity (micromhos/cm)	170
Total Suspended Solids (mg/L)	168
Ammonia-Nitrogen (mg/L as N)	0.08
Total Kjeldahl Nitrogen (mg/L as N)	2.05
Nitrate (mg/L)	3.18
Phosphorus	0.55
Phosphorus, Dissolved (mg/L)	0.30

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Environmental and Natural Resources Consulting and Analytical Services

DATE: August 8, 1988
*Amended: December 1, 1988
**Amended: February 27, 1989

CTI REPORT NO: DO 8012

CTI LAB NO: W8806285

PROJECT NO.: **188

TO: Jim Buckles

REPORT ON TESTING OF WATER SAMPLES

SOURCE OF SAMPLE: Donan/**Lake Salinda - LSR2 - 10:30 A.M.

DATE OF COLLECTION: *7/20-21/88

DATE RECEIVED: 7/22/88

SAMPLE TYPE: Grab

PARAMETER	CONCENTRATION
pH	7.2
Dissolved Oxygen (mg/L) (readings taken in lab 7/25)	7.6
Conductivity (micromhos/cm)	107
Total Suspended Solids (mg/L)	444
Ammonia-Nitrogen (mg/L as N)	0.10
Total Kjeldahl Nitrogen (mg/L as N)	2.30
Nitrate (mg/L)	2.38
Phosphorus	0.55
Phosphorus, Dissolved (mg/L)	0.13

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DATE: August 8, 1988
*Amended: December 1, 1988
**Amended: February 27, 1989

CTI REPORT NO: DO 8013

CTI LAB NO: W8806286

PROJECT NO.: **188

TO: Jim Buckles

REPORT ON TESTING OF WATER SAMPLES

SOURCE OF SAMPLE: Donan/**Lake Salinda LSR3 - 10:30 A.M.

DATE OF COLLECTION: *7/20-21/88

DATE RECEIVED: 7/22/88

SAMPLE TYPE: Grab

PARAMETER	CONCENTRATION
pH	7.2
Dissolved Oxygen (mg/L) (readings taken in lab 7/25)	7.0
Conductivity (micromhos/cm)	144
Total Suspended Solids (mg/L)	488
Ammonia-Nitrogen (mg/L as N)	0.31
Total Kjeldahl Nitrogen (mg/L as N)	2.50
Nitrate (mg/L)	3.54
Phosphorus	0.77
Phosphorus, Dissolved (mg/L)	0.31

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DATE: August 8, 1988
*Amended: December 1, 1988
**Amended: February 27, 1989

CTI REPORT NO: DO 8014

CTI LAB NO: W8806287

PROJECT NO.: **188

TO: Jim Buckles

REPORT ON TESTING OF WATER SAMPLES

SOURCE OF SAMPLE: Donan/** lake Salinda - LRS5 - 3:35

DATE OF COLLECTION: *7/20-21/88

DATE RECEIVED: 7/22/88

SAMPLE TYPE: Grab

PARAMETER	CONCENTRATION
pH	7.3
Dissolved Oxygen (mg/L) (readings taken in lab 7/25)	7.9
Conductivity (micromhos/cm)	210
Total Suspended Solids (mg/L)	988
Ammonia-Nitrogen (mg/L as N)	0.05
Total Kjeldahl Nitrogen (mg/L as N)	10.2
Nitrate (mg/L)	7.91
Phosphorus	1.71
Phosphorus, Dissolved (mg/L)	0.51

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DATE: August 8, 1988
*Amended: December 1, 1988
**Amended: February 27, 1989

CTI REPORT NO: DO 8015

CTI LAB NO: W8806288

PROJECT NO.: **188

TO: Jim Buckles

REPORT ON TESTING OF WATER SAMPLES

SOURCE OF SAMPLE: Donan/**Lake Salinda - LSR 6 - 11:20 A.M.

DATE OF COLLECTION: *7/20-21/88

DATE RECEIVED: 7/22/88

SAMPLE TYPE: Grab

PARAMETER	CONCENTRATION
pH	7.2
Dissolved Oxygen (mg/L) (readings taken in lab 7/25)	7.8
Conductivity (micromhos/cm)	193
Total Suspended Solids (mg/L)	92
Ammonia-Nitrogen (mg/L as N)	0.09
Total Kjeldahl Nitrogen (mg/L as N)	1.28
Nitrate (mg/L)	4.62
Phosphorus	0.49
Phosphorus, Dissolved (mg/L)	0.35

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Environmental and Natural Resources Consulting and Analytical Services

DATE: August 8, 1988
*Amended: December 1, 1988
**Amended: February 27, 1989

CTI REPORT NO: DO 8016

CTI LAB NO: W8806289

PROJECT NO.: **188

TO: Jim Buckles

REPORT ON TESTING OF WATER SAMPLES

SOURCE OF SAMPLE: Donan/**Lake Salinda LSR 7 - 3:23

DATE OF COLLECTION: *7/20-21/88

DATE RECEIVED: 7/22/88

SAMPLE TYPE: Grab

PARAMETER	CONCENTRATION
pH	7.0
Dissolved Oxygen (mg/L) (readings taken in lab 7/25)	7.6
Conductivity (micromhos/cm)	208
Total Suspended Solids (mg/L)	972
Ammonia-Nitrogen (mg/L as N)	0.46
Total Kjeldahl Nitrogen (mg/L as N)	7.00
Nitrate (mg/L)	7.13
Phosphorus	1.48
Phosphorus, Dissolved (mg/L)	0.56

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Environmental and Natural Resources Consulting and Analytical Services

Date: September 6, 1988

CTI Report No.: DO 8020

CTI Lab No.: See Below

CTI Project No.: 188

To: Jim Buckles

Report on Testing of Sediment Samples

Source of Sample: Lake Salinda 880804 (See Below)

Date of Collection: 8/4/88

Date Received: 8/5/88

Sample Type: Grab

CTI Lab NO.	Sample ID	Nitrate-Nitrogen (mg/Kg as N)	Ammonia-Nitrogen (mg/Kg as N)	Total Kjeldahl Nitrogen (mg/Kg as N)	Phosphorus Total (mg/Kg as P)	Phosphorus Available (lb/ac)
W8806531	LSS1	<3.70	63.0	1000	54.4	<5
W8806532	LSS2	<2.15	1.60	900	72.1	<5
W8806533	LSS5	<6.94	1.00	1000	343	93
W8806534	LSS4	<2.31	0.80	800	104	<5

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AQUATIC WEED SURVEY

Edward G. Foree, Ph.D., P.E.

John S. Tapp, Ph.D., P.E., L.S.

COMMONWEALTH TECHNOLOGY, INC.

Environmental and Natural Resources Consulting and Analytical Services

Aquatic Weed Identification

Report Date: 8/10/88

CTI Rep. No.: MT10025
Project: Lake Salinda
Project No: 188
I.D. by J. Stein

To: Mike Tackett

Date of Collection: 8/04/88
Date Received: 8/04/88
Sample Type: Grab

Sample I.D.	Common Name	Scientific Name
LS-1	Torpedo grass	Panacum repens
LS-2	Cattail	Typha sp.
LS-3	American pondweed	Potomogeton nodosus
LS-4	Duckweed	Lemna minor

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COMMONWEALTH TECHNOLOGY, INC.

Environmental and Natural Resources Consulting and Analytical Services

CTI Algae Identification

Report Date: 8/10/88

CTI Report No.: MT10027
Project : Lake Salinda
Project No.: 188
Identification by: Jeff Stine

To: Mike Tackett

Date of Collection: 8/04/88
Date Received: 8/04/88
Sample Type: Grab
Sampling Depth: 0-5' Tow

Sample ID	Scientific Name
LSA1	*Netrium digitus*
LSA3	*Cosmarium*
LSA4	*Scenedesmus quadricauda*
LSA5	*Gonium pectorale*
LSA10	*Anabaena*
LSA2	*Chlamydomonas*
LSA6	*Staurastrum*
LSA9	*Pandorina morum*
LSA11	*Cladophora*

Plankton count was more than 10,000/ML
Blue Green Algae was not dominant.

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Environmental and Natural Resources Consulting and Analytical Services

CTI Algae Identification

Report Date: 8/10/88

CTI Report No.: MT10028
Project : Lake Salinda
Project No.: 188
Identification by: Jeff Stine

To: Mike Tackett

Date of Collection: 8/04/88
Date Received: 8/04/88
Sample Type: Grab
Sampling Depth: 5' to Thermocline

Sample ID	Scientific Name
LSA13	<u>Pediastrum</u>

Plankton count was 30,000 or more per ML.
Blue Green Algae was not dominant.

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PHOTOGRAPHIC DOCUMENTATION

INDEX OF PHOTOGRAPHS
LAKE SALINDA

PHOTO #	DESCRIPTION
1	Lake Salinda Dam and Spillway, shows sampling stations LS1, and LS2.
2	Watershed Section 6, shows emergent plants and land use/topography in basin.
3	Pool near Dam and LS2, shows Duckweed covering lake surface.
4	Secchi Disk being submerged @ station LS2.

1

2

3

4

PHOTO #	DESCRIPTION
1	Left bank near station LS2 showing Duckweed on Lake surface.
2	Watershed Section 6 outlet, showing cattails near shore and dam in background.
3	View of Lake pool and dam from near stations LS3.
4	View from boat launch area (LS4) shows outlet of watershed section 5 in background.


1


2


3


4

PHOTO #	DESCRIPTION
1	Taken from Watershed Section 5 inlet, shows emergent plants near shore.
2	View from station LS4 towards LS5 and Section 4 inlet.
3	View from LS5 toward inlet watershed.
4	View from LS5 towards sediment delta and aquatic vegetation.


1


2


3


4

PHOTO #	DESCRIPTION
1	Station LS4 towards Section 4 inlet.
2	View from near LS4 towards Section 3 inlet.
3	Watershed Section 6 showing cattails.
4	Watershed Section 2 inlet showing emergent plants.


1


2


3


4

MISCELLANEOUS INFORMATION

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MODEL #	DESCRIPTION	QUANTITY	PRICE EA.	TOTAL
AWC-4/KS-1	Aqua Weed Cutter w/ Super Sharpener		$84.95	
AWR-1	Aqua Weed Rake		$89.95	
			Subtotal	
			C.O.D. fee	
			sales tax*	
			Grand Total	

*Michigan residents add 4% sales tax

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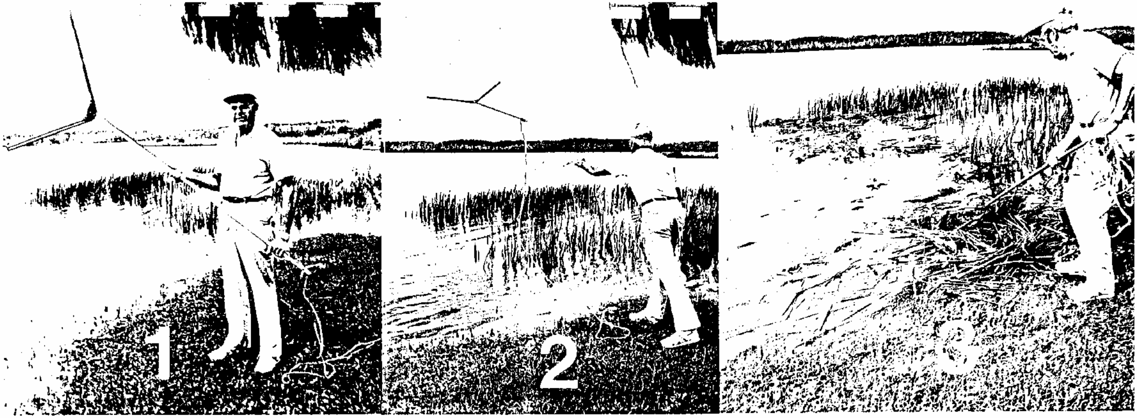

HANDY MARKETING CO.

Dear Friend:

If you have a water weed problem, you already know what a job it is keeping the weed growth under control. Water weeds can greatly affect the use of your water property by inhibiting swimming, fishing and boating. Uncontrolled water weeds can also be an unsightly mess.

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The AQUA WEED CUTTER is manufactured with the highest degree of workmanship and the highest quality of materials. The AQUA WEED CUTTER is 100% manufactured in the United States. Zinc plating and the stainless steel resharpenable blades offer a high degree of corrosion resistance. We are so sure of the quality of materials and workmanship that goes into each AQUA WEED CUTTER that we have recently extended the limited warranty period from 90 days to 1 year.

Sincerely,

Don Breckenridge

Don Breckenridge,
President

SATISFIED CUSTOMERS

"Does a fantastic job - I figured I cleared more weeds in two hours than I've previously been able to in a whole summer."
-South Haven, MI

"My friend brought his AWC over to my house and I tried it. I thought it was great and I ordered one. The AWC is effective and easy to use."
-Webster, WI

"I like it very much. It does a very good job. I had to put a longer rope on it because I can throw it farther than the rope would permit. It's nice to be able to cut weeds without getting wet, especially when the water is cold."
-Aitkin, MN

"Gentlemen, I wish to inform you that your AQUA WEED CUTTER does a very good job and I am pleased. Several of the neighbors have also ordered them."
-Gowen, MI

"We have tried the AQUA WEED CUTTER and find it does an excellent job of cleaning the weeds in our beach, along the long pier and boat docks. We are very satisfied with the product and would recommend it to anyone who has a need."
-Claypool, IN

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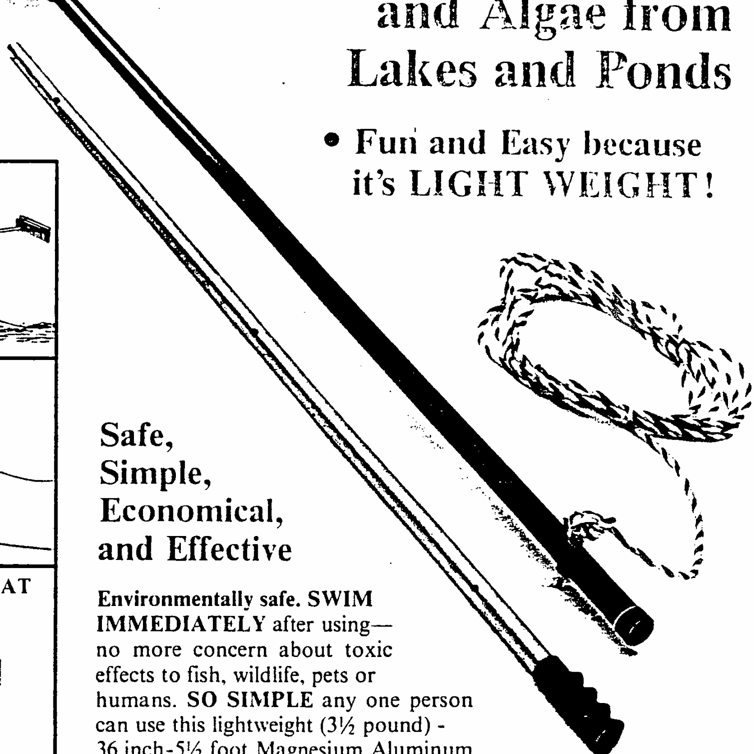

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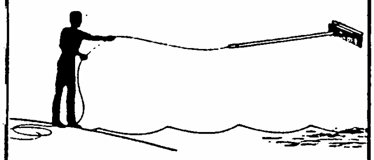
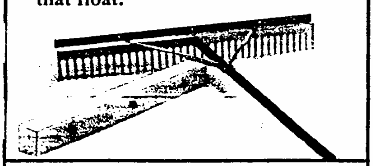
Just Throw it out and Rake in the weeds

Throw from Dock or Shore



Pull to shore while wading

ATTACHABLE FOAM FLOAT for removing Weeds & Algae that float.



Unwanted water weeds make excellent garden Fertilizer

Safe, Simple, Economical, and Effective

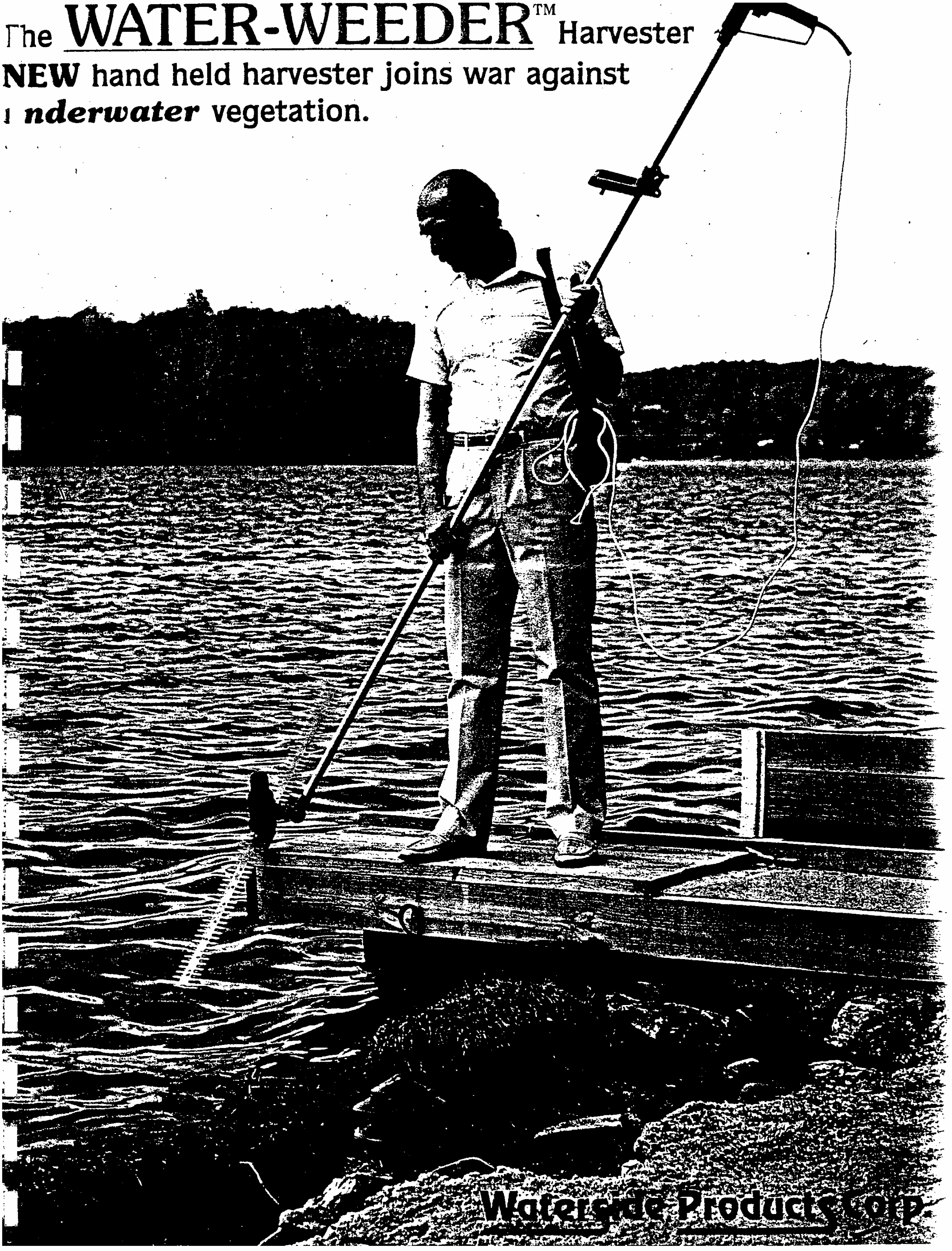
Environmentally safe. SWIM IMMEDIATELY after using— no more concern about toxic effects to fish, wildlife, pets or humans. **SO SIMPLE** any one person can use this lightweight (3½ pound) - 36 inch-5½ foot Magnesium Aluminum Rake. Adjustable extension (6′ to 10′) allows for removing weeds and debris from lake bottoms. **ECONOMICAL** because it provides many years of weed removal for less than the cost of chemical treatments. Ideal for fast and easy "Shoreline clean-up" or "Sand Raking" beaches or gardens. The Attachable Float makes the rake **MORE EFFECTIVE** for removing weeds that float.

- **What could be a better** companion tool for "Aqua Weed Cutter" owners?

HMc Dist. by HANDY MARKETING Co. • 4394 Airwest, S.E. • Grand Rapids, MI 49508 • PH 616 • 698-8335

The **WATER-WEEDER**™ Harvester

NEW hand held harvester joins war against underwater vegetation.

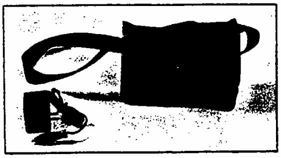


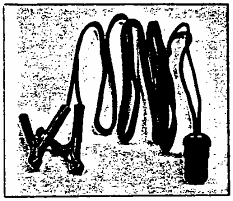
Accessories:

Twelve Volt Rechargeable Power Pack.

Will provide over one hour of continuous operation. Lightweight with custom carrying case. Recharges at least 500 times at ordinary household outlet. Charger included.

$79.99





Boat or Car Battery Adapter

Two foot long cable to quickly connect Harvester to your boat or car battery.

$7.99

Four Foot Shaft Extension

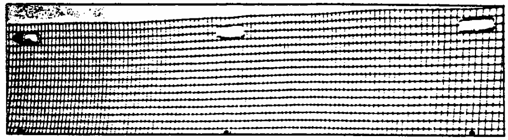
Provides the option of extending the cutting depth of the Harvester from eight feet to twelve feet.

$24.99

Specially Designed Collection Net

Included with your order!

30ft. Collection net with 13 Floatation buoys and 15 ft. of anchor line INCLUDED!



THE WATERSIDE GUARANTEE

Satisfaction Guaranteed or Your Money Promptly Refunded

If *within 14 days of receipt* you are *not* satisfied with the WATER-WEEDER™ harvesting tool *for any reason*, simply return it shipped prepaid. Waterside Products Corp. will promptly refund your complete purchase price.

Limited Product Warranty

Waterside Products Corp., warrants to the original purchaser that each new WATER-WEEDER™ harvesting tool is free from defects in material and workmanship and agrees to repair or replace under this warranty any defective tool within one (1) year from original date of purchase.

Commercial Applications

The term of the limited product warranty is reduced to ninety (90) days if the WATER-WEEDER™ harvesting tool is used commercially.

Full details of this Limited Product Warranty appear in the owners manual.

Order Form Call Toll Free or Write 1-800/552-1217

Name ______________________

Address ______________________

City ______________ State ____ Zip ________

Qty.	Item	Each	Total
	Harvester	$299.99	
	Battery Pack	79.99	
	Adapter	7.99	
	4 ft. Extension	24.99	
		Amount of Order	
		N.Y. State Residents — add Sales Tax	
		Shipping and Handling (Add$10.00 for each Harvester and $8.00 for each Battery Pack)	
		TOTAL	

PAYMENT METHOD

☐ Check enclosed payable to:
Waterside Products Corp.

☐ MasterCard ☐ VISA

Card Account Number:

_ _ _ _ _ _ _ _ _ _ _ _ _ _

Card Expiration Date ______ Customer Signature ______

Name of Bank Issuing Card: ______ Customer Phone # ______

or Call Toll Free

1/800-552-1217

In Canada call Collect 1/914-621-1155

Canadian Customers

Payment by International Money Order or U.S. Funds
or
Use your **VISA** or **MasterCard**

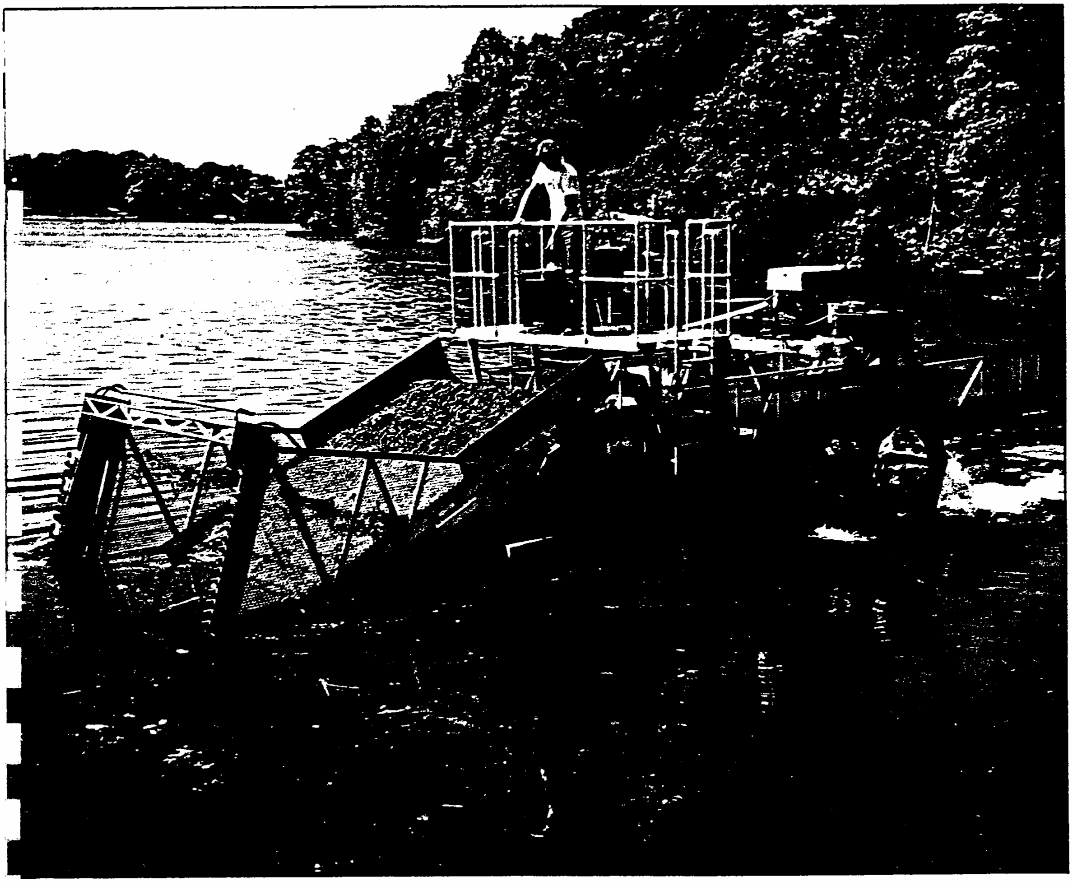
Waterside Products Corp.

P.O. Box 876, Lake Mahopac, New York 10541 USA

Office and Warehouse
108 Old Rt. 6
Lake Carmel, N.Y. 10512

AQUARIUS SYSTEMS

AQUATIC PLANT HARVESTING EQUIPMENT



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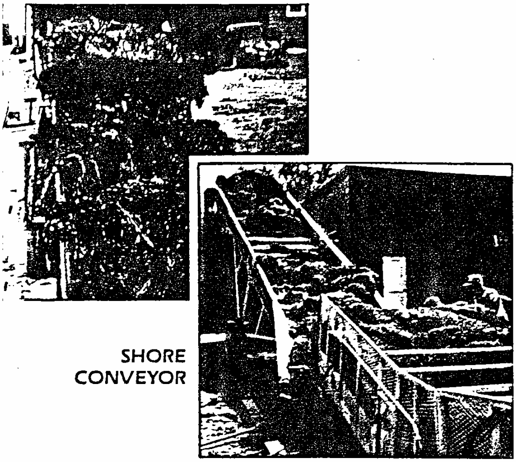
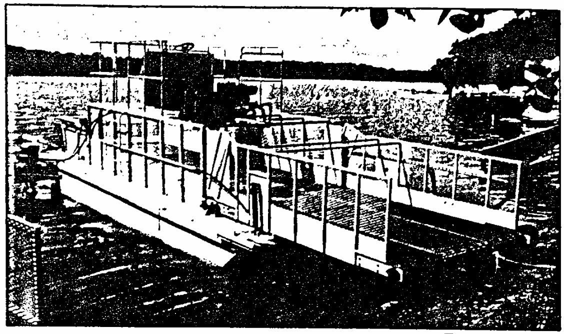
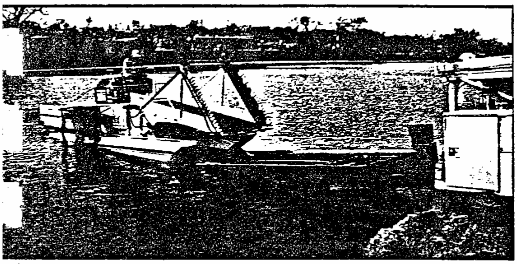


SHORE
CONVEYOR

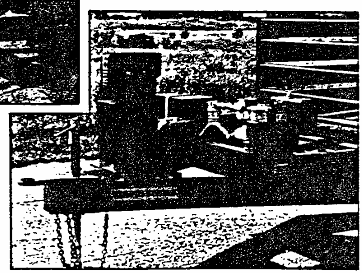


TRANSPORT

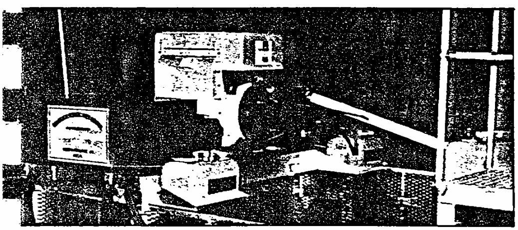
SHORE CONVEYOR TRANSPORT HARVESTER



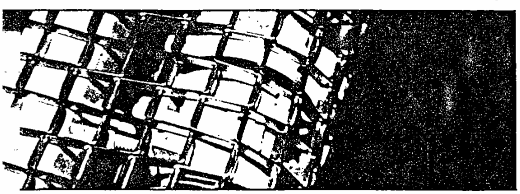
LAUNCHING



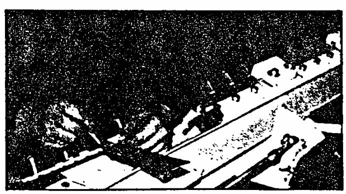
TRAILER/CONVEYOR



POWER PACK



CONVEYOR MESH



CUTTING KNIVES

AQUARIUS
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Treating lakes with alum: an overview

Bret Conover, Manager
Lake Management Services
General Chemical Corp.
Parsippany, NJ

Algae blooms, excessive vegetation and the odors and fish kills they cause plague lakes across the United States. In most cases, these problems are caused by dissolved nutrients from fertilizers, detergents and other sources of phosphate leaching.

A lake that has received waste-water for years may contain bottom muds so rich in organic matter that it becomes an ongoing source of phosphates. Even when the inflow of phosphate is eliminated, this nutrient remains in oversupply. Phosphates in sediment are released during summer when oxygen depletion in the lower layer of a lake allows them to redissolve.

Preventing problems caused by excessive nutrients is a twofold process: keeping nutrients out and eliminating the nutrients the lake already contains.

Federal and state laws restrict wastewater inflow to lakes from residences, agriculture and industry. But how to cleanse a lake of its nutrient content?

One proven method uses aluminum sulfate (alum), a nontoxic chemical applied in water and wastewater treatment plants to remove suspended solids and phosphates.

Alum is safe, effective and economical, and has been used for clarification of drinking water since the times of the ancient Romans and Egyptians. However, only in the past decade have lakes been treated with alum in North America and Europe, and only now is this method moving into the mainstream of lake treatment.

Alum works because it removes phosphates from the water column and seals in the phosphates contained in bottom mud. The lake bottom that lies within the cold deep layer of a thermally stratified lake is treated.

Most easily used in a liquid form, alum is either sprayed on the surface or injected underwater, in both cases from a boat or barge. Almost instantly, the alum forms a stable, relatively insoluble, gelatinous precipitate in the water that sweeps out suspended solids and removes dissolved phosphate as it sinks.

If enough alum is added, a thick precipitate layer will coat the bottom, sealing the sediments and inhibiting phosphate return to the water column. Laboratory and on-site tests determine the quantity of alum needed to form this protective coating.

To properly blanket the lake bottom, the vessel must make precise transits of the lake. In small lakes, shoreline markers guide the vessel. Large lakes demand more sophisticated means buoys or shore-based sonar, for example. The visible white precipitate that forms in the wake also aids navigation on calm days by marking the last path treated.

Alum treatment may take a few days or several weeks, depending on the size of the lake. The lake should be monitored for two years after treatment to determine the extent of phosphorus removal. Provided no further phosphorus enters the lake, alum treatment will control phosphate levels and eliminate algae blooms for many years.

SOILS MAP

THIS MAP IS TOO LARGE TO BE SCANNED FOR ON-LINE VERSION OF THIS DOCUMENT

AERIAL/WATERSHED LAND USE MAP

THIS MAP IS TOO LARGE TO BE SCANNED FOR ON-LINE VERSION OF THIS DOCUMENT